Voyager

B U L L E T I N

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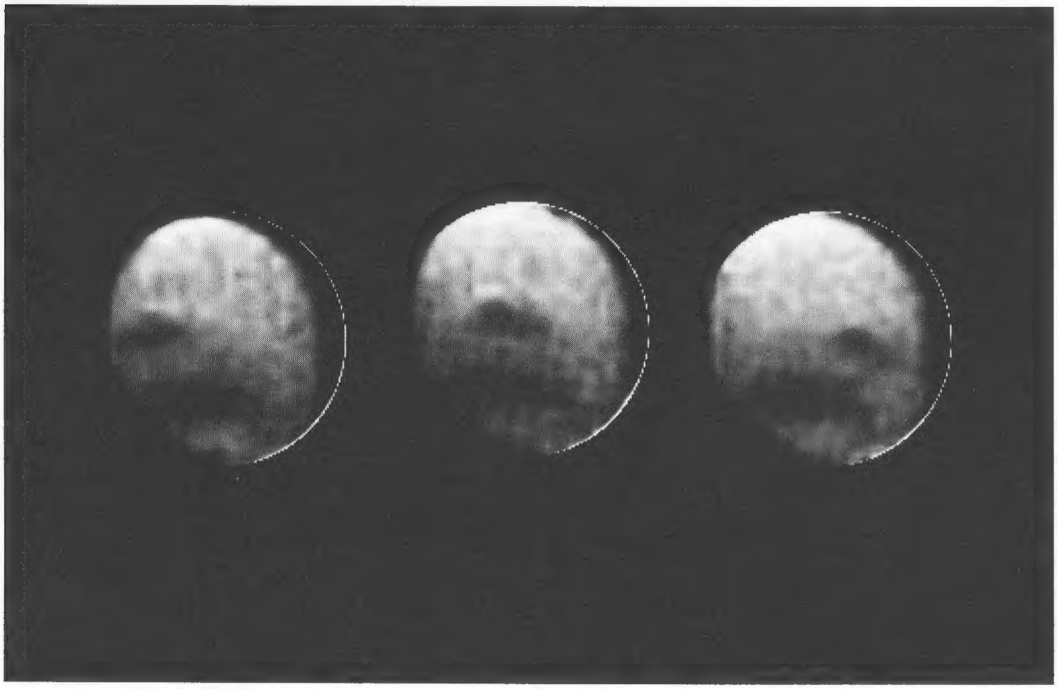


A dark band encircles Neptune's south pole, while a large dark spot in the southern hemisphere rotates around the planet with a period between 17 and 18 hours. (P-34192)

Does Neptune have a Great Spot?

A large dark spot and a dark band encircling the south polar region of Neptune are visible in images acquired 90 minutes apart by Voyager 2 on April 3, 1989, from a distance of 208 million kilometers (129 million miles). The spot rotates around the planet in 17 to 18 hours.

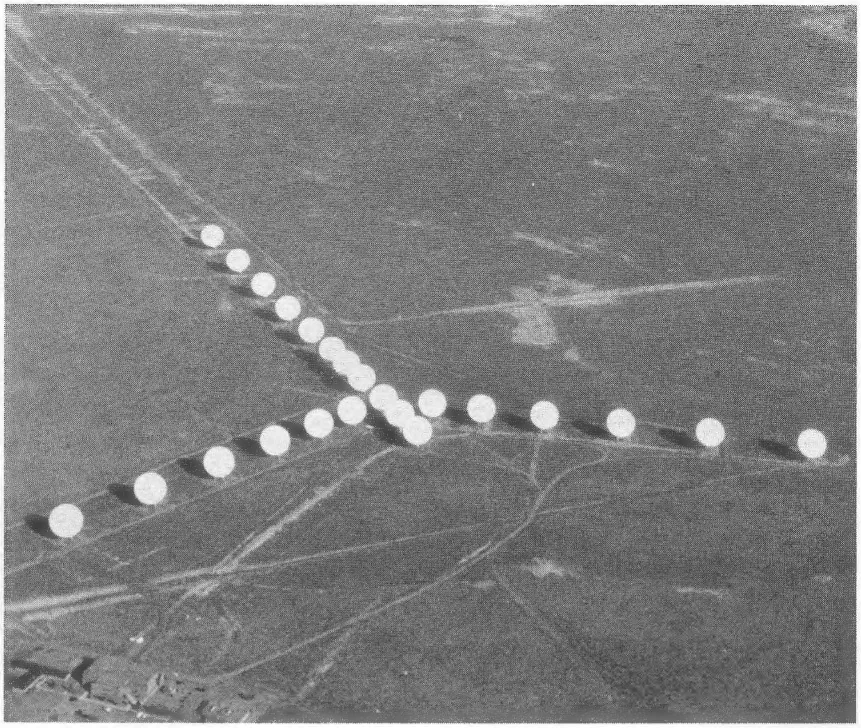
Detection of the spot will allow atmospheric scientists to determine rotation rates of features in the planet's atmosphere much earlier than had been expected. Voyager 2's cameras will track cloud features over the next several months.

The spot extends from 20 degrees south to 30 degrees south latitude, and spans 35 degrees in longitude. Relative to the size of Neptune, the dimensions of the spot are comparable to Jupiter's Great Red Spot.

The images were taken through the narrow-angle camera's clear filter, which is most sensitive to blue light. The spot is 10 percent darker than its surroundings. The smallest object that can be seen in these images is about 3850 kilometers (2400 miles) across.

Scientists have not yet determined whether this is the same spot seen in images taken 70 days earlier in late January. The spot seen in the January images appears dark through the clear filter but bright through the orange filter. Features seen through the orange filter may be at higher altitudes than those visible in these most recent images.

The jagged white rim on the right edges of the images are processing artifacts.



The antennas of the Y-shaped Very Large Array spread across the plains in central New Mexico. (JPL 2816A)

Very Large Array

For Voyager's Neptune encounter this summer, a new data-acquisition partnership has been forged with the Very Large Array (VLA), a unique radio astronomy instrument in west-central New Mexico.

As spacecraft travel farther from Earth, the strength of the signal received at Earth weakens, primarily due to the great distance traveled* . By the time Voyager 2's signals from Neptune (about 4.5 billion kilometers away) reach Earth, they will be less than half as strong as those received from Voyager 2 from Uranus (about 3 billion kilometers from Earth) in 1986.

The telemetry data rate would be reduced by the same amount if improvements had not been made in the data acquisition facilities on Earth.

To capture Voyager 2's data from Neptune, NASA's Deep Space Network (DSN) has upgraded their three 64-meter antennas to 70 meters and made them more efficient, built a new high-efficiency 34-meter antenna at the Madrid complex, combined signals from several antennas, and added non-DSN antennas to the system.

The technique of combining the weak signals received at several antennas into a single, stronger signal is known as arraying. During Voyager's Saturn encounters in 1980 and 1981, adjacent 64-meter (210-foot) and 26-meter (85-foot) antennas at DSN sites were successfully arrayed. The technique was extended during the Uranus encounter in 1986, when the Canberra Deep Space Complex was arrayed with the Australian government's Parkes Radio Observatory antenna 275 kilometers (170 miles) away. For Neptune, Parkes and Canberra will once again be arrayed, and the VLA will be arrayed with the DSN antennas at Goldstone, in California's Mojave Desert.

The VLA, a complex of twenty-seven 25-meter (82-foot) antennas (plus a spare), is a part of the National Radio Astronomy Observatory (NRAO) operated by Associated Universities, Inc., under a cooperative agreement with the National Science Foundation. The VLA will track Voyager 2's signal this summer and send the raw data via satellite to Goldstone. There, the signals from VLA will be electronically combined with Voyager signals received by Goldstone's antenna array (at least one 70-meter [230-foot] and one or two 34-meter [111.5-foot] antennas). Use of the VLA will add the equivalent of about one and a half 70-meter antennas to the Network.

The Voyager partnership with NRAO–VLA started in 1982 when it was recognized that should Voyager 2 survive to fly past Neptune, greater receiving capability was required. An interagency Memorandum of Understanding between NASA and the National Science Foundation was signed in 1984.

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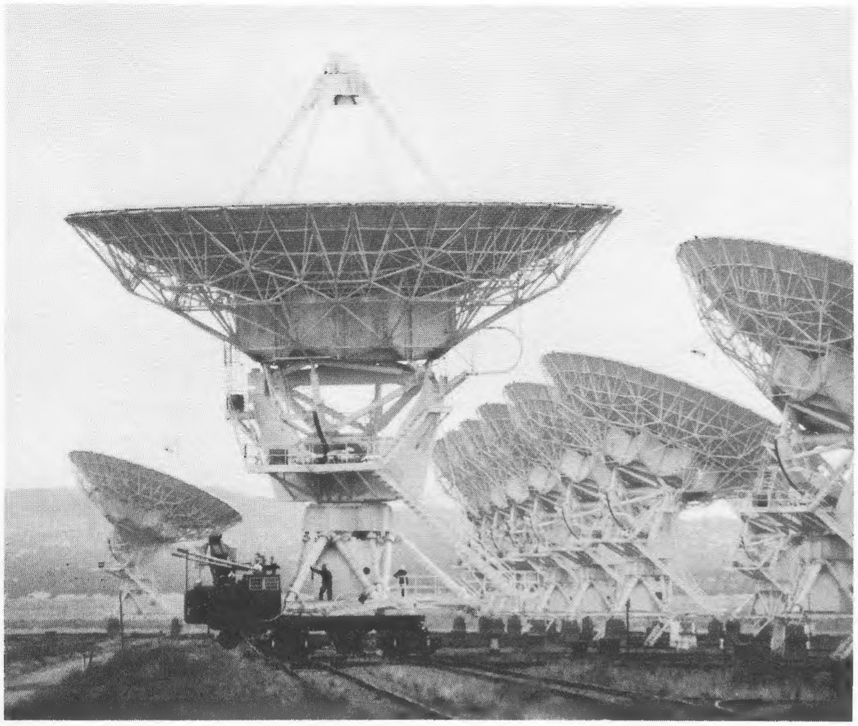
*A formula known as the inverse-square law is used to estimate the decrease in signal strength: radio signals weaken according to the ratio of the squares of the distances from the transmitter to the receiver. At the time of Uranus flyby in 1986, for example, Uranus was at about 19 AU (an astronomical unit (AU) is the average distance from the Sun to the Earth, about 150 million kilometers or 93 million miles), while Neptune will be at 30 AU. Therefore, $19^2/30^2 = 361/900 = 0.4$. In other words, the signals received from Voyager 2 at Neptune will be about 40 percent as strong as those that were received from Uranus.



The 230-ton antennas are moved to different foundations by transporter vehicles traveling over 40 miles of railroad tracks. (JPL 3763)

All that remained was to await the Congressional go-ahead for Voyager 2 to be sent on to Neptune. The Neptune mission was approved in 1985.

The arraying techniques and upgrades to the DSN antennas mean that the Network will be able to reliably capture a maximum data rate from Voyager at Neptune of 21,600 bits per second (bps), about the same as the DSN could capture during the Uranus encounter in 1986. Without these improvements in the ground facilities, the maximum data rate would have been 14,400 bps and only for brief periods each day. (In 1965, Mariner 4's date rate from Mars [at 1.5 AU] was only 8-1/3 bits per second.)

What is the VLA?

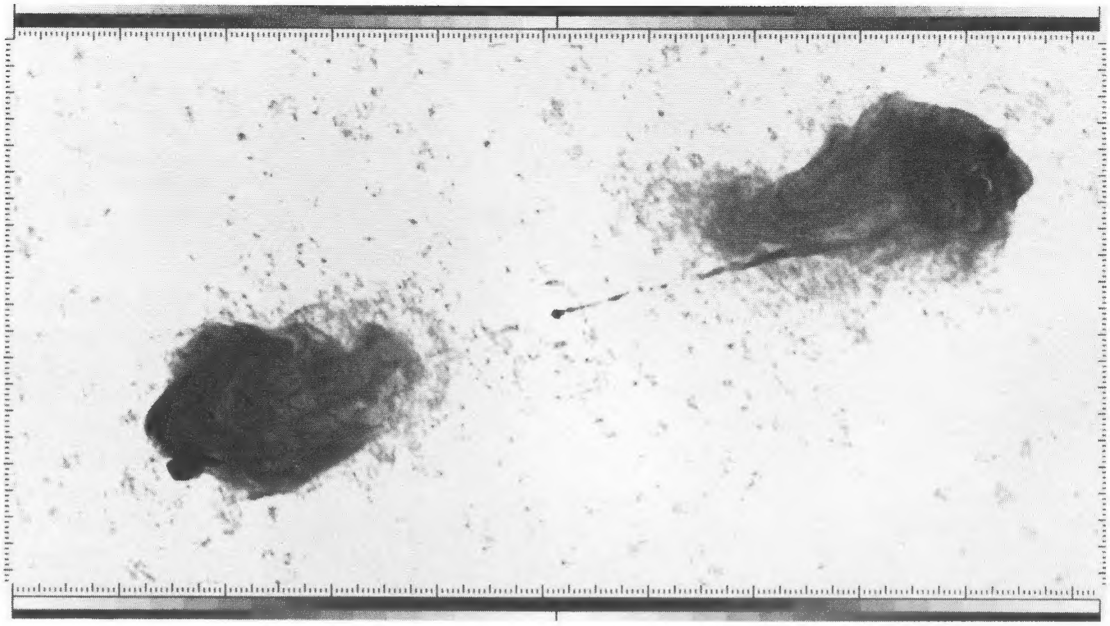
The VLA is a radio astronomy instrument that is used to detect and map fine detail in distant radio sources to gain a better understanding of the physical processes involved in distant galaxies that emit radio radiation. The VLA makes images using radio waves, whose nature is similar to light but whose wavelength is many thousand times longer and thus cannot be seen by the human eye.

Strong emitters of radio radiation, such as "radio" galaxies, emit between a thousand and a million times more radio radiation than other galaxies do. Radio astronomers use instruments such as the VLA, with its great sensitivity and resolving power (the ability to distinguish between two objects very close to each other), to investigate the nature of the processes occurring in radio galaxies.

The VLA consists of 27 dish-shaped antennas arranged in a Y-shape spreading across the Plains of St. Augustin about 50 miles west of Socorro, New Mexico. The captured signals are electronically combined (arrayed) to effectively form a single large radio telescope. The combining is done in the VLA control center, where a special purpose computer compares (multiplies) the signal from each antenna with every other antenna, calculating the time difference and signal interference for each pair, for a total of 351 interferometer pairs. This multiplication is done 100 million times a second.

Each 230-ton antenna can be moved to different foundations on the "Y" by transporter vehicles riding on railroad tracks. Four basic configurations are used, ranging from clustering the antennas to within 0.6 kilometer (2000 feet) of the center of the array, to stretching them out so that the most distant antenna is 21 kilometers (13 miles) from the center. To track Voyager 2, the antennas will be positioned near the center of the array, but slightly modified in spacing so that the south-facing antennas won't shadow each other.

The antennas are physically connected by underground waveguides—tubes through which electronic signals travel from the antennas to the control center. At regular intervals, the wave flow is reversed to send control signals from the control center to the antennas, briefly interrupting the data flow. The architecture of Voyager's Reed-Solomon data encoding system on board the spacecraft largely overcomes any degradation in these intervals after the signals from the VLA and Goldstone are combined at Goldstone.



The VLA is a radio astronomy instrument that is usually used to study objects such as the radio galaxy Cygnus A, rather than interplanetary spacecraft. (Courtesy NRAO/AUI) (Acknowledgment: R.A. Perley, J.W. Dreher, and J.J. Cowan)

Upgrades to the VLA

To be able to support Voyager, the VLA site needed a number of upgrades. First, all of the antennas were fitted with new receivers able to capture Voyager's X-band signals (about 8.4 gigahertz, or 8.4 billion cycles per second). These receivers include low-noise amplifiers which are helium-cooled to temperatures of about 15 kelvins (-430°F) to reduce internally generated noise which tends to mask the very weak radio signals from space. The amplifiers use state-of-the-art devices called high-electron mobility transistors (HEMTs) which allow a faster flow of electrons across the layers of the semiconductor but create less heat. The HEMTs are credited with improving the performance of the system beyond what had been initially planned. The upgrade to X-band receivers took about four years, done over the VLA's normal maintenance cycle. The new VLA capability at X-band will be used for other science such as planetary radar, very-long-baseline interferometry, imaging continuum emissions, and imaging spectral-line emissions and absorptions.

JPL has also provided new signal-processing equipment similar to that implemented in Australia for the Canberra/Parkes array.

A study of the VLA power system, consisting of power purchased from the overhead grid of the local electric utility company, showed that the system was vulnerable to voltage transients and outages due to severe wind and lightning storms, for example. To minimize the risk of losing any of the irreplaceable first images from Neptune, the VLA has been equipped with two diesel generators, each rated to deliver 1400 kilowatts, to assure a steady supply of reliable, high-quality power during Voyager tracking periods. Although one generator alone is capable of supplying the total power required, the two generators will operate in parallel, each loaded at 50 percent of their rating.

Data from the VLA will be routed to Goldstone via a microwave link using a geosynchronous satellite. At Goldstone, the signals received at VLA and at Goldstone will be combined. The data will be recorded at both sites to prevent loss of data should the satellite link fail.

In addition to the hardware and software upgrades, three DSN operators will be located at the VLA to coordinate and monitor the operation of the VLA–Goldstone Telemetry Array.

NASA

National Aeronautics and Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

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Editor
Anita Sohus (818) 393-0683

Technical Review
Voyager Project Staff

Public Information Office
(818) 354-5011

Public Education Office
(818) 354-8594